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Fifth day of August 2004

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**AUSTRALIA  
PATENTS ACT, 1990**

**PROVISIONAL SPECIFICATION**

**FOR THE INVENTION ENTITLED:**

**"Mill Relining Apparatus"**

**Applicant: Ross Clive Allen**

**The invention is described in the following statement:**

## **FIELD OF THE INVENTION**

The present invention relates to a mill relining apparatus. In particular, although not exclusively, the invention may be employed to aid in the handling, removing and/or installing of liners and lifters within a sagmill or ballmill.

## **BACKGROUND TO THE INVENTION**

Ballmills and sagmills are used in the minerals industry to grind ore into small particles. Typically, the mills comprise cylindrical-shaped steel milling chambers filled with steel balls, also known as the mill charge. A conveyor or hopper moves ore gravel into the mill and the mill is rotated causing the steel balls themselves to cascade, which in turn grinds the ore.

The nature of the intense fracturing and grinding that occurs in the mills requires that the shell of the mill be protected to prevent deterioration. Typically, the protection is achieved by lining the inner wall of the mill shell with plate liners and separate bolted lifters made of hardened steel.

Depending on the size of the mill, i.e. its diameter and length, there may be well over 100 mill liners and lifters each typically weighing well over 100 kilograms. As the mill is operated, the intense fracturing and grinding wears the mill liners and lifters, and replacement becomes necessary. The relining process is necessary to maintain the integrity of the mill shell and to improve the efficiency of the mill grinding process by increased material lift from the new lifters and liners.

The relining process involves taking the mill out of service, and sequentially removing the worn liners and lifters and replacing them with new liners and lifters. Typically, liners are retained by the lifter bolts through the shell of the mill and these lifter bolts must first be removed before the liner or lifters can be moved from the shell of the mill. To remove a lifter bolt its nut is loosened from the exterior of the mill shell and the lifter bolt is punched through into the mill. Once the lifter bolts have been removed the worn

liner and lifter can be removed from the inner wall of the shell and a new one can be bolted in their place.

It is essential that the relining process is undertaken as quickly as possible as any downtime with the mills out of service can be costly and for this reason various handling machines and tools are often used to aid in the relining process. Further, such handling machines and tools are often essential due to the size and weight of the liners and lifters.

One such known handling machine for use within a mill during a relining process involves inserting a track into an open end or entry of a mill, for example through the center of the mill's bearing. The track forms a pathway for a carriage, adapted with a remote handling arm, to move along within the mill. Typically, the carriage's remote handling arm has a grapple assembly or the like for handling mill liners and lifters and the handling arm is operable to permit the handling arm to aid in the relining process. Other known handling machines do not use a track within the mill and operate by simply extending a single arm through a large entry point in the mill which can run around the inside of the mill handling and placing liners and lifters.

Such handling machines are suitable for larger mills, for example mills of 12 meters in diameter, which have large end entry points, for example openings of up to 2 meters in diameter through the mill's end bearing. However, these machines can not often be used for smaller mills with small entry points or openings. Therefore, the relining process for smaller sized mills conventionally involves removing and replacing liners and lifters by hand. This can be a time consuming and costly operation, not only because of the mill downtime but because a significant amount of manual labour is required.

It is an object of the present invention to provide a mill relining apparatus suited for use in smaller sized mills and/or which at least provides the public with a useful alternative.

## **SUMMARY OF THE INVENTION**

In one aspect, the present invention broadly consists in a mill relining apparatus for handling and/or placing articles within a mill, including: a mast which is extendible in length; and one or more article handling arrangements adaptable to or extending from the mast to facilitate handling and/or placing articles; wherein the mast may be locked into a substantially upright position within a mill by resting a lower part of the mast on the mill charge or a bottom inner wall section or liner of the mill and extending the mast so an upper part of the mast engages with a top inner wall section or liner of the mill.

Preferably, a hydraulic system is adapted to the mast to facilitate extension of the mast. Suitably, the hydraulic system includes a hydraulic cylinder and hydraulic ram which is moveable within the hydraulic cylinder. Alternatively, a pneumatic system is adapted to the mast to facilitate extension of the mast.

Suitably, the mast includes two parts, a base mast part and an extension mast part. Preferably, the extension mast part is slidable or telescopic relative to the base mast part.

Preferably, the hydraulic system is adapted to the mast such that the hydraulic cylinder is coupled to the base mast part and the hydraulic ram is coupled to the extension mast part. More preferably, the hydraulic system may be controlled so that extension or retraction of the hydraulic ram from or into the hydraulic cylinder causes a corresponding slidable movement of the extension mast part relative to the base mast part, thereby enabling adjustable extension of the mast length.

Preferably, the hydraulic system includes an accumulator which maintains a substantially constant pressure within the hydraulic cylinder to maintain the mast in an extended position during use. More preferably, the accumulator includes a shell which encloses a flexible rubber bladder. Typically, the flexible rubber bladder is pre-charged to a predetermined pressure with a gas, such as nitrogen. Generally, the accumulator maintains a substantially constant pressure within the hydraulic cylinder in response to

movement in the mill charge which the lower part of the mast rests on and/or loading of the article handling arrangement.

In a preferred embodiment, the article handling arrangement includes a jib with a top end and a bottom end which is adaptable to the mast. Preferably, the extension mast part has a bottom pivot plate near its bottom end and a top engagement plate near its top end. Preferably, the jib may be fitted to the mast so that the bottom end of the jib engages with the bottom pivot plate and the top end of the jib engages with the top engagement plate.

Preferably, the jib is adapted for rotation relative to the mast. More preferably, the bottom pivot plate and top engagement plate provide pivotal connections with which the jib ends engage. Suitably, the bottom pivot plate and top engagement plate pivotal connections define an axis about which the jib may rotate.

Typically, the position of the bottom pivot plate on the extension mast part is adjustable to allow alignment of the jib.

Suitably, the article handling arrangement further includes a boom adapted or connected to the jib. Preferably, the boom is extendible in length. Preferably, the longitudinal axis of the boom is substantially perpendicular to the axis of the mast. In a preferred embodiment, the boom may be connected at more than one position on the jib.

Typically, the boom includes two parts, a base boom part and an extension boom part. Suitably, the base boom part is fixed to the jib and the extension boom part is adapted for movement relative to the base boom part to extend or reduce the boom's length. More suitably, the movement of the extension boom part is facilitated via a roller arrangement.

Preferably, a connection to facilitate the loading of articles or to facilitate the attachment of auxiliary equipment for handling and/or placing articles is provided at or towards a distal end of the extension boom part.



Typically, the article handling arrangement may further include a guy line which is connected between the top end of the jib and the end of the base boom part distal to the jib.

Preferably, the mast includes one article handling arrangement. Alternatively, the mast may include two article handling arrangements to facilitate handling and/or placing articles on opposite sides of the substantially upright mast simultaneously.

In an alternative embodiment, the article handling arrangement includes a boom which is adapted for movement up and down along the length of the mast. Preferably, a winch system adapted to the mast and boom facilitates the movement. More preferably, the winch system includes a cable connected to the boom which loops around a pulley connected at or towards the top of the mast and down to a winch also connected to the mast. Generally, the winch is operable to wind or unwind the cable and thereby move the boom up or down the mast respectively.

Preferably, the boom is extendible in length. More preferably, the boom includes two parts, a base boom part and an extension boom part. Generally, the base boom part has a slidable member which may be coupled to the mast to facilitate movement. Suitably, the extension boom part is adapted for movement relative to the base boom part to extend or reduce the boom's length. Preferably, the movement of the extension boom part is facilitated via a roller arrangement.

Preferably, the longitudinal axis of the boom is substantially perpendicular to the axis of the mast. More preferably, a connection to facilitate loading of articles or to facilitate the attachment of auxiliary equipment for handling and/or placing articles is provided at or towards a distal end of the extension boom part.

Preferably, the upper part of the mast has a top plate. More preferably, the top plate is made of rubber. Even more preferably, the top inner wall section of the mill to which

the upper part of the mast may extend towards is a mill liner and the rubber top plate is shaped to securely engage with that mill liner.

Preferably, the lower part of the mast has a bottom base plate. More preferably, one or more tines are provided on the underside of the bottom base plate and are configured to extend into the mill charge when the lower part of the mast rests on the mill charge.

Preferably, the articles to be handled and/or placed are mill liners and lifters.

Preferably, the mill is a sagmill or ballmill.

In another aspect, the present invention broadly consists in a method of relining a mill using the mill relining apparatus outlined in the first aspect above.

This invention may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more said parts, elements or features, and where specific integers are mentioned herein which have known equivalents in the art to which this invention relates, such known equivalents are deemed to be incorporated herein as if individually set forth.

The invention consists in the foregoing and also envisages constructions of which the following gives examples only.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Preferred embodiments of the invention will be described by way of example only and with reference to the drawings, in which:

Figure 1 shows a cross-sectional side elevation view of a mill with a first preferred embodiment mill relining apparatus installed within, in particular showing a mast in a substantially upright locked position extending between the mill charge and a top liner



and an article handling arrangement comprising a jib and boom arrangement connected to the mast;

Figure 2 shows a cross-sectional end elevation view of a mill with the mill relining apparatus of Figure 1 installed within, in particular showing the mill shell with worn and new mill liners and lifters;

Figure 3 shows an elevation view of the first preferred embodiment mill relining apparatus from direction D of Figure 2;

Figure 4 shows a cross-sectional end elevation view of a mill with a second preferred embodiment mill relining apparatus installed within, in particular showing a mast configured with two article handling arrangements comprising jib and boom arrangements on opposite sides of the mast; and

Figure 5 shows a cross-sectional end elevation view of a mill with a third preferred embodiment mill relining apparatus installed within, in particular showing a mast adapted with an article handling arrangement comprising an extendible boom which is adapted for movement up and down the length of the mast.

#### **DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS**

A first preferred embodiment mill relining apparatus will be described with reference to Figures 1, 2, and 3. Referring initially to Figure 1, the first preferred embodiment mill relining apparatus 1 is shown installed within a mill 3. The mill 3 is a ballmill or sagmill which has a cylindrically-shaped and elongate shell 25 and has a number of steel balls which fill a lower portion of the shell 25, and which constitute the mill charge 7.

The relining apparatus 1 includes a mast 5 with a lower part 27 and upper part 29, and which is extendible in length. The upper part 29 of the mast 5 has a top plate 23 and the lower part 27 of the mast 5 has a bottom base plate 19.

Figure 1 illustrates the relining apparatus 1 in a fully assembled and installed position within the mill 3. The mast 5 is in a substantially upright position and has been extended in length to lock the mast 5 securely in place within the mill. The bottom base plate 19 of the mast 5 rests on the surface of the mill charge 7. The mast 5 is locked in a substantially upright position by virtue of an extension of the mast's 5 length such that the top plate 23 of the mast securely engages with one of the mill liners 99 located on the top inner wall section of the mill's shell 25.

To reduce the movement of the bottom base plate 19 of the mast 5 with respect to the surface of the mill charge 7, one or more tines 21 are provided on the underside of the bottom base plate 19. When the bottom base plate 19 of the mast 5 rests on the surface of the mill charge 7, the tines 21 extend into the mill charge 7 and reduce the likelihood that the bottom base plate 19 will slip or slide along the surface of the mill charge 7. The tines 21 have spiked ends to facilitate the insertion of the tines 21 into the mill charge 7. In the preferred embodiment the bottom base plate 19 is square and a tine 21 is located in each of the four corners of the bottom base plate 19.

The relining apparatus 1 includes a hydraulic system (not all components shown) which facilitates extension of the mast's 5 length. The hydraulic system includes a hydraulic cylinder 15 and a hydraulic ram 17 which is moved by the hydraulic cylinder 15. The hydraulic cylinder 15 and ram 17 are coupled to portions of the mast 5 to facilitate its extension.

The relining apparatus 1 includes an article handling arrangement 31, which is adapted to the mast 5. The article handling arrangement 31 includes a jib 9 which is connected to the mast 5 and a boom 11 which is connected to the jib 9. The boom 11 is extendible in length and is provided with a connection 33 at its end distal to the jib 9 to facilitate the loading of articles such as mill liners or lifters or connection of auxiliary devices which handle mill liners or lifters. Such auxiliary devices may include pneumatic or hydraulic winches, remote handling arms, grapples and the like.

The article handling arrangement 31 is also provided with a guy wire 13 which extends between an upper end of the jib 9 and a portion of the boom 11. The guy wire 13 provides support for the boom 11, which in use may be loaded up with articles weighing in excess of 100 kilograms.

Referring to Figure 2, the article handling arrangement 31 of the relining apparatus 1 is shown in more detail. The mast 5 includes a top engagement plate 37 and bottom pivot plate 39 to facilitate connection of the article handling arrangement 31 to the mast 5.

The jib 9 of the article handling arrangement 31 comprises upper 43 and lower 41 support arms which are integrally formed or attached together at a junction 49 to form a wide substantially v-shaped jib 9. The jib 9 includes a support cross member 45 which extends between the upper 43 and lower 41 support arms. Further, the jib 9 includes a supporting lattice work structure 47 which is situated between the support cross member 45 and upper 43 and lower 41 support arms.

An upper engagement member 57 protrudes from an upper end 55 of the upper support arm 43 of the jib 9. Similarly, a lower engagement member 59 protrudes from a lower end 53 of the lower support arm 41 of the jib 9. The upper 57 and lower 59 engagement members are cylindrical in shape.

The top engagement plate 37 and bottom pivot plate 39 are configured with connection apertures (not shown) which are adapted to receive the upper 57 and lower 59 engagement members of the jib 9 to form pivotal connections when fitting the jib 9 to the mast 5. When the jib 9 is installed on the mast 5, the upper 57 and lower 59 engagement members of the jib 9 may pivot within their respective connection apertures. In this respect, the connection apertures in the top engagement 37 and bottom pivot 39 plates are aligned to form an axis around which the jib 9, and ultimately the article handling arrangement 31, may rotate by virtue of the pivotal connections. In the preferred embodiment, the jib 9 has a degree of rotational freedom of approximately 180° about the axis which the top engagement 37 and bottom pivot 39 plates of the mast 5 provide.

The bottom pivot plate 39 is slidably mounted to a fixed mounting plate 38 provided on the mast 5 so that the position of the bottom pivot plate 39 relative to the mast 5 can be adjusted.

The bottom pivot plate 39 is secured to the fixed mounting plate 38 of the mast 5 via two fastening arrangements 61. In the preferred embodiment, the fastening arrangements 61 comprise nut and bolt fasteners. Each nut and bolt fastener 61 is configured so that the bolt of the fastener 61 extends through an aperture (not shown) in the fixed mounting plate 38 and through a corresponding elongate slot in the bottom pivot plate 39. The nut of each fastener 61 is threaded onto the end of the bolt and tightened to secure the bottom pivot plate 39 to the fixed mounting plate 38.

To adjust the position of the bottom pivot plate 39, the nut of each of the fastening arrangements 61 can be loosened to allow the bottom pivot plate 39 to be slidably moved with respect to the fixed mounting plate 38. The extent of slidable movement available is dependent on the length of the slots in the bottom pivot plate 39. Once the position adjustment is complete, the bottom pivot plate 39 may again be fixed in place to the fixed mounting plate 38 by sufficiently tightening each nut of the fastening arrangements 61.

The ability to adjust the position of the bottom pivot plate 39 enables the jib 9 to be aligned into a plumb upright position. Such alignment is important for safety reasons to ensure that the jib 9 does not arbitrarily under gravity swing about the pivotal connections of the top engagement 37 and bottom pivot 39 plates when the boom 11 connected to the jib 9 is loaded up with a mill liner, lifter or the like.

The article handling arrangement 31 includes a boom 11 which is adapted to the jib 9. The longitudinal axis of the boom 11 is substantially perpendicular to the axis of the mast 5 and the length of the boom 11 is extendible.

The boom 11 includes two parts, a base boom part 63 and an extension boom part 65, wherein the extension boom part 65 is moveable relative to the base boom part 63 to facilitate boom 11 extension. The base boom part 63 is connected to the junction 49 of the jib 9 at one end by a fastening arrangement 48, such as a nut and bolt arrangement. It will be appreciated that the base boom part 63 may be connected at other positions on the jib 9, for example at any of the connections 50 on the lower support arm 41 or any of the connections 52 on the upper support arm 43. This enables the overall height of the boom 11 above the mill charge 7 to be adjustable.

A guide member 69 is provided at the other end of the base boom part 63 distal to the jib 9. The extension boom part 65 has a slidable connection 67 at one end which facilitates its connection and moveable relationship with the base boom part 63. The other end of the extension boom part 65 extends through the guide member 69 of the base boom part 63.

Both the guide member 69 of the base boom part 63 and slidable connection 67 of the extension boom part 65 are configured with rollers, 73 and 71 respectively. The rollers 73 and 71 facilitate the movement of the extension boom part 65 relative to the base boom part 63 to enable the overall extension of the boom 11 to be adjusted as required.

The extension boom part 65 has a connection 33 at the end opposite to the slidable connection 67. The connection 33 can be adapted to load liners and lifters, or can be adapted to other auxiliary equipment which is capable of handling and/or placing liners and lifters. For example, the connection 33 may comprise an aperture to which a loading cable or auxiliary equipment could be attached to or hooked onto.

It will be appreciated that there are other ways of providing a boom which is adjustable in length. For example, the boom could include a telescopic arrangement powered by pneumatics or hydraulics, or the like

To provide additional support and strength to the article handling arrangement 31, a guy wire 13 is connected between a connection point 74 formed near the top of the upper



support arm 43 of the jib 9 and a connection point 75 near the guide member 69 of the base boom part 63. The length of the guy wire 13, or its tension, may be adjusted to ensure the boom 11 is level. The guy wire 13 could be a cable, rope, chain or the like.

As mentioned above, the upper part 29 of the mast 5 has a top plate 23 and the lower part 27 of the mast 5 has a bottom base plate 19. In the preferred embodiment, the bottom base plate 19 is connected to the lower part 27 of the mast 5 by a fastening arrangement 79, for example a nut and bolt arrangement. Similarly, the top plate 23 is connected to the upper part 29 of the mast 5 by a fastening arrangement 77, for example a nut and bolt arrangement.

In the preferred embodiment, the top plate 23 is formed from rubber and is resiliently deformable to engage securely with the surface of a worn mill liner 99. In the preferred embodiment, the top plate 23 is a mill rubber lifter, and its position on the upper part of the mast is adjustable.

It will be appreciated that the top plate 23 may be formed from other types of material and may be shaped differently according to the surface to which it is to be engaged with.

Referring to Figure 3, the mast 5 of the relining apparatus 1 comprises two parts, a base mast part 81 and an extension mast part 83. The base mast part 81 is attached at one end to the bottom base plate 19 and the extension mast part 83 is connected at one end to the rubber top plate 23.

The top engagement plate 37 to which an end of the jib 9 engages is connected near the top end of the extension mast part 83, while the bottom pivot plate 39 to which the other end of the jib 9 engages is connected near the bottom end of the extension mast part 83. The extension mast part 83 is substantially longer than the base mast part 81. The mast 5 parts are all substantially square in cross-section, although it will be appreciated that circular or rectangular cross-sectional components would be suitable also.

A portion of the base mast part 81 forms the lower part 27 of the mast 5 and a portion of the extension mast part 83 forms the upper part 29 of the mast 5. The extension mast part 83 includes an enlarged base portion 83a integrally formed with or attached to a longer upper portion 83b of reduced cross-sectional area relative to the enlarged base portion 83a.

A portion of the base mast part 81 may extend into the enlarged base portion 83a of the extension mast part 83 and the arrangement is such that slidable movement of the extension mast part 83 relative to the base mast part 81 is enabled. It will be appreciated that an opposite arrangement is possible such that the extension mast part 83 may extend within the base mast part 81 to form a slidable arrangement.

As mentioned above, the relining apparatus 1 includes a hydraulic system (not all components shown) to control and power the slidable movement of the extension mast part 83 relative to the base mast part 81, thereby controlling the length of extension of the mast 5. The hydraulic system includes a hydraulic cylinder 15 which is attached to the bottom base plate 19 and is coupled by a connection 87 to the base mast part 81. A hydraulic ram 17, which is moveable within the hydraulic cylinder 15, is coupled by a connection 85 to the enlarged base portion 83a of the extension mast part 83.

With the mast 5 coupled to the elements of the hydraulic system, extension or retraction of the hydraulic ram 17 from or into the hydraulic cylinder 15 causes a corresponding slidable movement of the extension mast part 83 relative to the base mast part 81, thereby enabling the overall length of the mast 5 to be adjusted.

It will be appreciated that the extension of the mast 5 may be achieved in other ways, for example the mast may be a powered telescopic mast comprising a number of segments. Further, a pneumatic system could be used instead of a hydraulic system to control the extension of the mast.

In the preferred embodiment, the hydraulic system may also include an accumulator (not shown). The accumulator maintains a substantially constant pressure within the

hydraulic cylinder 15 to maintain the mast 5 in an extended and locked substantially upright position within a mill 3 when the relining apparatus 1 is being used to handle and/or place liners or lifters.

In the preferred embodiment, the accumulator consists of a shell which encloses a flexible rubber bladder. The accumulator is connected to the hydraulic line which pumps fluid into the hydraulic cylinder 15. The flexible rubber bladder is pre-charged to a predetermined pressure with a gas, such as nitrogen. When the hydraulic system forces hydraulic fluid through the shell of the accumulator and into the hydraulic cylinder 15, the gas inside the bladder of the accumulator compresses until the gas pressure becomes equal to the hydraulic system pressure. For example, if the hydraulic system pressure were 2 ton, the bladder would compress until the nitrogen gas pressure was 2 ton. Should the pressure of the hydraulic fluid within the hydraulic cylinder 15 fall, the bladder expands and forces more fluid into the cylinder, thereby maintaining a constant pressure within the hydraulic cylinder 15. A pressure fall in the hydraulic cylinder may occur, for example, in response to movement of the steel balls of the mill charge 7 which may potentially destabilise the mast 5 or loading of the article handling arrangement 31.

It will be appreciated that the hydraulic system could be adapted to suit different requirements, such as different mill sizes or loads. For example, a larger cylinder and ram arrangement may be required for larger mills. Further, the hydraulic system pressure may be adjusted to suit different levels to maintain the structural integrity of the relining apparatus during use.

Referring to Figures 1-3, a typical installation of the preferred embodiment relining apparatus 1 within a mill 3 will be described. The relining apparatus 1 is transported into the mill 3 in pieces through an opening in the end of the mill 3. Typically, the base mast part 81, extension mast part 83, rubber top plate 23, hydraulic cylinder 15 and ram 17 are pre-connected outside the mill 3 and then transferred into the mill as one component. The bottom base plate 19, jib 9, boom 11, guy wire 13 and remaining hydraulic components are transferred into the mill 3 separately. The unmentioned

components will typically be pre-connected to the various major parts before they are transported to within the mill 3.

The first stage in assembling and installing the relining apparatus 1 within the mill 3 is erecting the mast 5. This involves connecting the mast 5 component, with the pre-connected rubber top plate 23 and hydraulic cylinder 15 and ram 17, to the bottom base plate 19. With the mast 5 component connected to the bottom base plate 19, the mast 5 may be supported in a substantially upright position by virtue of the bottom base plate 19 resting on the mill charge 7 with tines 21 extending into the mill charge 7.

With the mast 5 erected, the remainder of the hydraulic system can be installed, which involves connecting hydraulic lines between a hydraulic pump and the hydraulic cylinder 15 and ram 17, and connecting the accumulator to the appropriate hydraulic line. The hydraulic system can then be actuated, thereby pressurising the hydraulic cylinder 15, and accumulator, and enabling the length of the mast 5 to be extended until the rubber top plate 23 engages securely with a liner 99 in the top inner wall of the mill 3, thereby locking the mast 5 in a substantially upright position within the mill 3. Adjustment of the mast 5 position may be required to ensure it is plumb. Once the mast 5 is suitably extended and adjusted, the hydraulic fluid line to the hydraulic cylinder 15 can be locked off. The accumulator then maintains a constant pressure within the hydraulic cylinder 15.

With the mast 5 locked in a substantially upright position, the jib 9 may be fitted to the top engagement 37 and bottom pivot 39 plates of the extension mast part 83. Adjustment of the bottom pivot plate 39 is then undertaken to fix the jib 9 in a plumb position to reduce the likelihood that the jib will arbitrarily swing under gravity. The boom 11 can then be fitted to the jib 9 at one of the connection points on the upper 43 or lower 41 support arms or at the junction 49. To finish the assembly the guy wire 13 is connected between the jib 9 and boom 11. The length of or tension on the guy wire 13 is adjusted to ensure the boom 11 is level.

The installed relining apparatus 1 can then be utilised to handle and/or place mill liners or lifters within the mill during the relining process. Typically, a hydraulic or pneumatic winch would be connected to the boom's 11 connection 33 and the winch would be used to load the boom 11 with an article, for example a liner or lifter. Other auxiliary devices may be connected to the boom 11 such as remote handling arms, grapples and the like.

With the boom 11 loaded, the article handling arrangement 31 may be moved to position the article within the mill 3 as desired. The article may be moved by swinging the article handling arrangement 31 relative to the mast 5 or by extending or retracting the boom 11, or a combination of the two. In the preferred embodiment, the article handling arrangement 31 has a degree of rotational freedom of approximately 180° relative to the mast 5. Further, if a winch is adapted to the connection 33 of the boom 11, this may be used to alter the height of the loaded article. With these ranges of motion, there is significant freedom to place, hold and suspend articles at various locations within the mill 3. For example, if a worn liner were being replaced, the relining apparatus could be utilised to suspend the new replacement liner in place while it was securely bolted to the mill's shell.

Typically, the mill 3 will have to be rotated during the relining process to provide access to all the worn liners and lifters. The mill relining apparatus 1 should be disassembled and removed from the mill 3 when it is rotated, and then reassembled, although it is possible to rotate the mill 3 slightly without disassembling the relining apparatus 1.

Typically, the relining apparatus 1 would be used in combination with an endless conveyor 93 which extends through the center bearing opening and into the mill 3. The conveyor 93 could be used to transport new liner and lifters to within the mill, where they could then be loaded onto the relining apparatus 1 and moved around the mill as required. The relining apparatus 1 could also be used to aid in transferring worn liner and lifters from their positions within the mill 3 to the conveyor 93, where they could then be removed from the mill 3.



As shown in Figure 2, a moveable platform 97, which operates externally to the mill 3, would also typically be used in the relining process along with the relining apparatus 1 to enable an operator to remove and install lifter bolts as required.

It will be appreciated that the rotation of the article handling arrangement 31 relative to the mast 5, and the extension of the boom 11 may also be powered in other ways, for example with motors, pneumatics, or hydraulics. Further, the relining apparatus 1 may include an overall control system, which is remote or inline with the relining apparatus 1, and which can control various aspects of the relining apparatus 1, for example the boom 11 extension, mast 5 extension, article handling arrangement 31 rotation, and control of any winch loading mechanism or other auxiliary equipment connected to the boom 11.

It will be appreciated, that the relining apparatus 1 may also be installed and used within a mill which does not contain a mill charge. In these circumstances, the bottom base plate 19 would not have tines 21, and would simply rest on the surface of a liner on a bottom inner wall section of the mill.

Referring to Figure 4, a second preferred embodiment relining apparatus 2 is depicted. In this embodiment the mast 5 is configured with two article handling arrangements 31, 32 which are situated on opposite sides of the mast 5. This embodiment allows the relining apparatus 2 to be utilised on both sides of the mill 3 at once to increase efficiency. Other than the additional article handling arrangement 32, the relining apparatus 2 embodies substantially all of the same features as outlined in respect of the first embodiment apparatus.

Typically, when using the relining apparatus 2 of the second preferred embodiment to work on both sides of a mill 3, one article handling arrangement is used to remove and replace worn liners and lifters on one side of the mill 3, while the other article handling arrangement is used only to remove worn lifters and liners on the other side of the mill 3. This process will depend on which way the mill 3 is rotated to expose more worn liners and lifters. For example, assuming that the mill 3 is rotated clockwise, article

handling arrangement 31 would be utilised to remove and replace liners and lifters on the right side of the mill 3 and article handling arrangement 32 would be utilised to only remove liners and lifters on the left side of the mill 3. This process is generally utilised because the orientation of the mill 3 would make it difficult to also replace liners and lifters on the left side due to their weight. During rotation of the mill 3, the relining apparatus 2 is disassembled and removed from the mill 3. Once the mill 3 is rotated a certain amount, for example to expose a further 3 liners, the relining apparatus 2 needs to be reassembled within the mill 3.

Moveable platforms 6 and 8 on the left and right sides of the mill 3 respectively would also typically be utilised to aid in the removal of lifter bolts.

Referring to Figure 5, a third preferred embodiment relining apparatus 101 is shown. This preferred embodiment utilises a different article handling arrangement 125 than that illustrated and described in the first and second embodiments. The article handling arrangement 125 includes a boom 105 which is adapted for slidable movement up and down the mast 121.

The boom 105 is extendible in length and includes two parts, a base boom part 109 and an extension boom part 107. The extension boom part 107 is adapted for movement relative to the base boom part 109 via rollers 127 and 129 configured in an arrangement similar to that described in respect of the first and second embodiments. The longitudinal axis of the boom 105 is substantially perpendicular to the axis of the mast 121.

In this embodiment, instead of the base boom part 109 of the boom 105 being connected to a jib, the base boom part 109 is adapted with a slidable member 103 which is coupled to the mast 121 to facilitate movement of the boom 105 along the length of the mast 121.

A winch system is adapted to the mast 121 and boom 105 to facilitate the movement of the boom 105 up and down the mast's 121 length. The winch system includes a cable

111 connected to the base boom part 109 of the boom 105 which loops around a pulley 115 connected near the top of the mast 121 and down to a winch 119 also connected to the mast 121. The pulley is connected to near the top of the mast 121 by a pivotal connection member 117.

The winch 119 may be actuated to wind or unwind the cable 111 and thereby move the boom 105 up and down the mast 121. The ability to alter the height of the boom 105 is important when the relining apparatus 101 is used within a smaller mill where space is minimal. It enables workers within the mill to have the option of moving the boom 105 lower down the mast 121 so that they can step over it or higher up the mast 121 so they can step under it, which ever is more suitable to them for the task they are performing in the relining process.

The three foregoing preferred embodiments may be disassembled so that they can be transferred into a small mill with a relatively small opening, and then reassembled once all the components are inside the mill. For example, the relining apparatus of the first preferred embodiment may be installed within a mill which is about 5.2 meters in diameter, and which has an opening in the end of approximately 0.9 meters in diameter. A mill of this size typically has in the order of 350 liners weighing approximately 115 kilograms each and 214 lifters weighing approximately 145 kilograms each. The relining apparatus may also be fully scalable to suit larger or smaller mills.

The foregoing description of the invention includes preferred forms thereof. Modifications may be made thereto without departing from the scope of the invention.

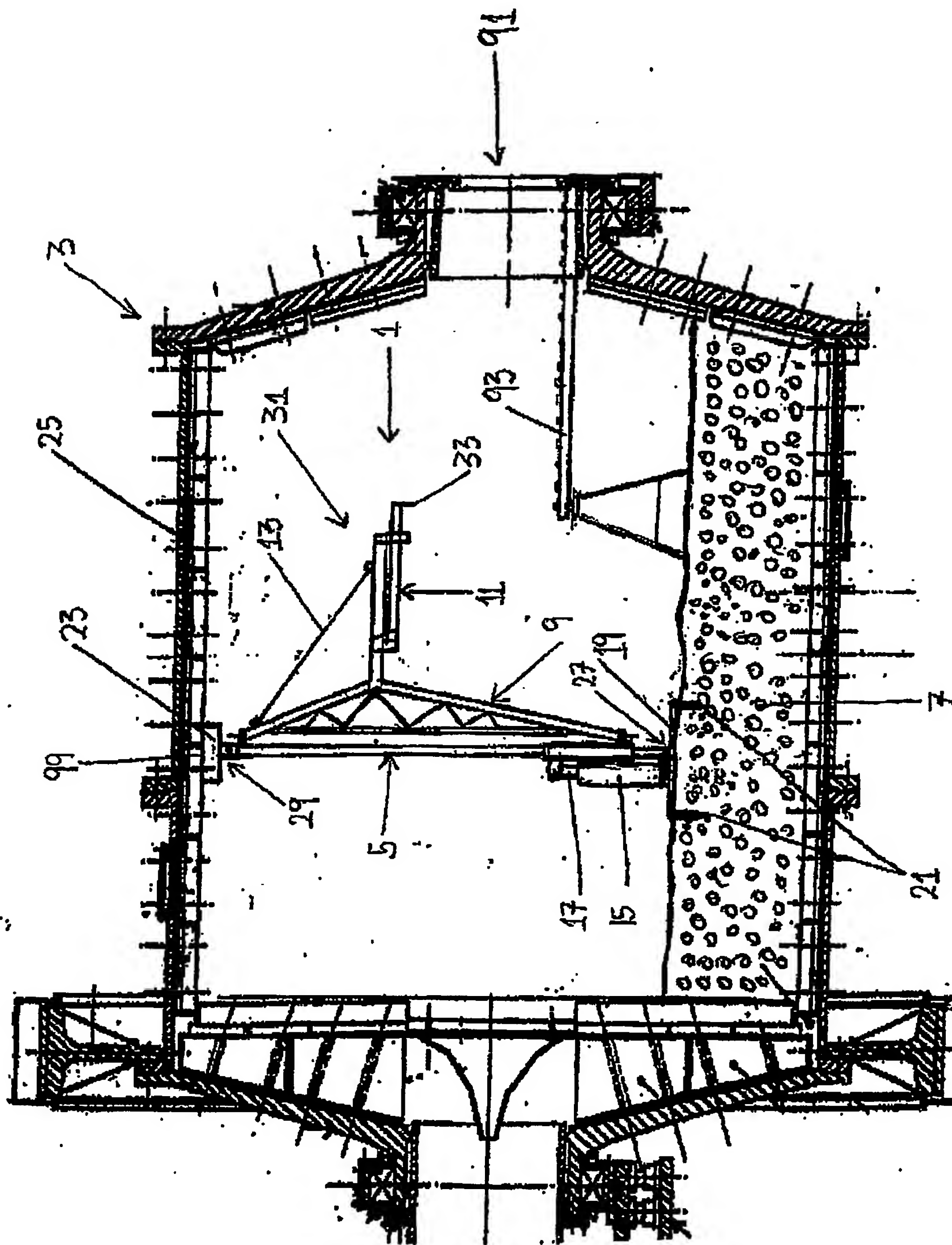


FIGURE 1/5

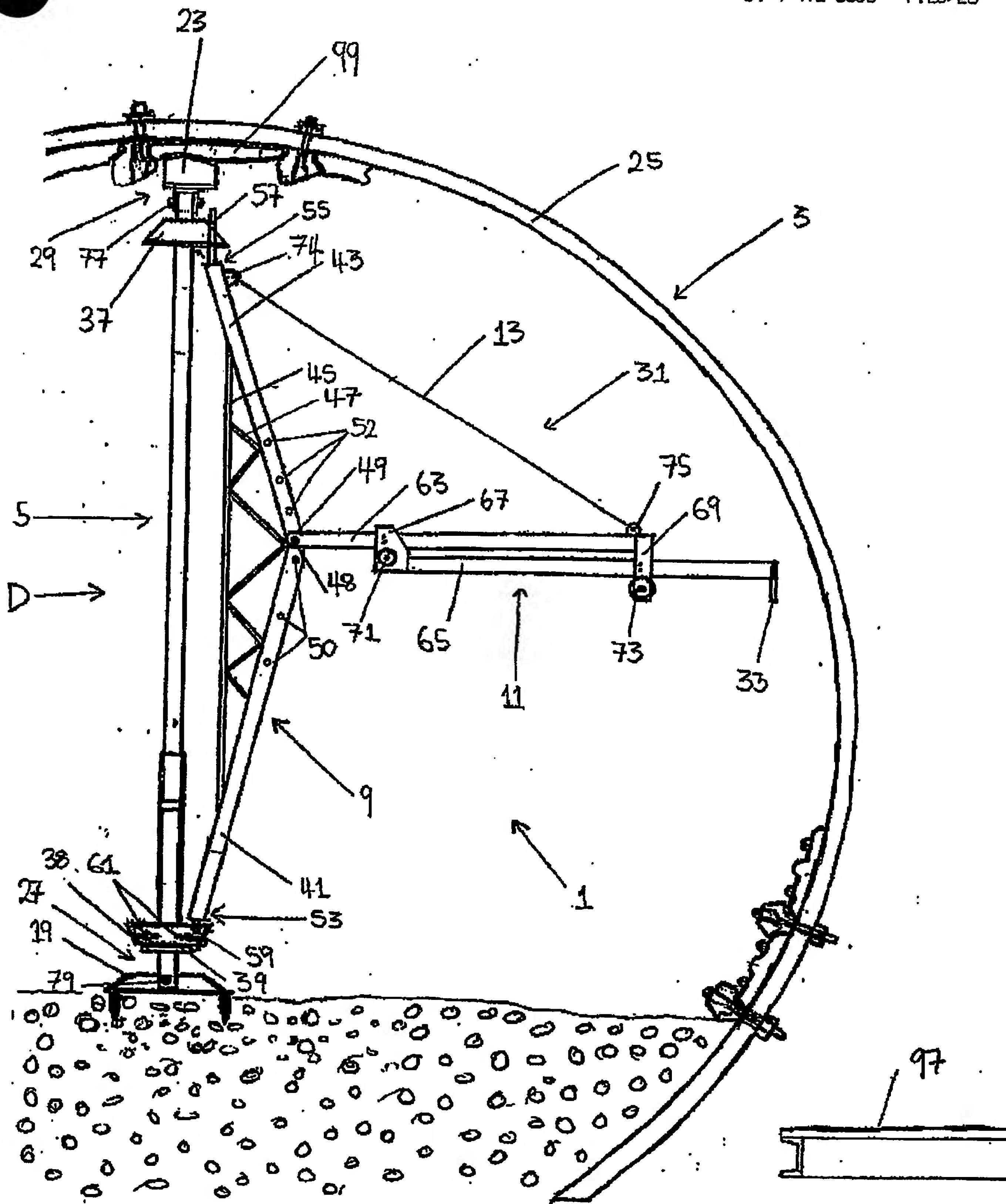


FIGURE 2/5



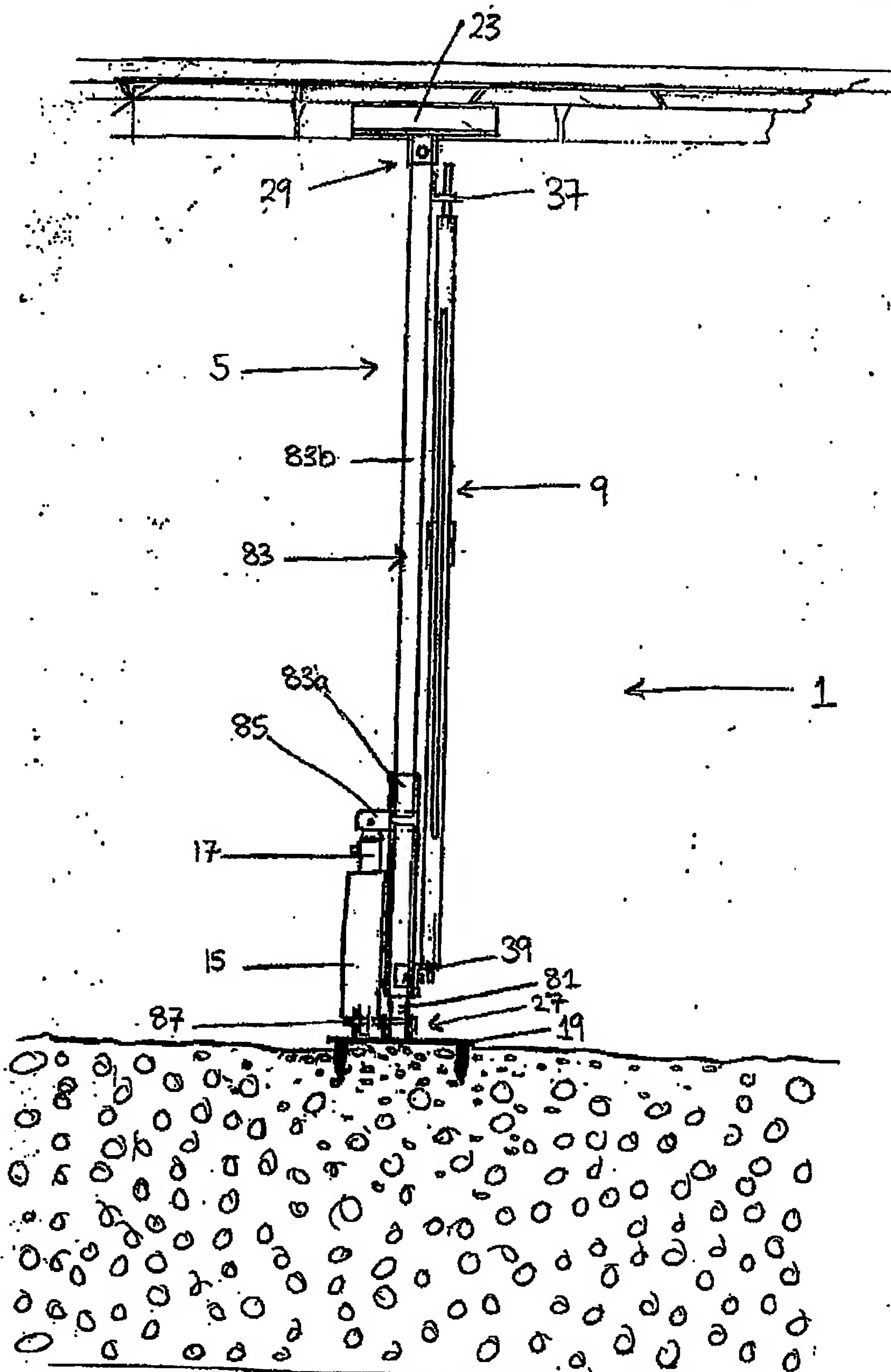


FIGURE 3/5

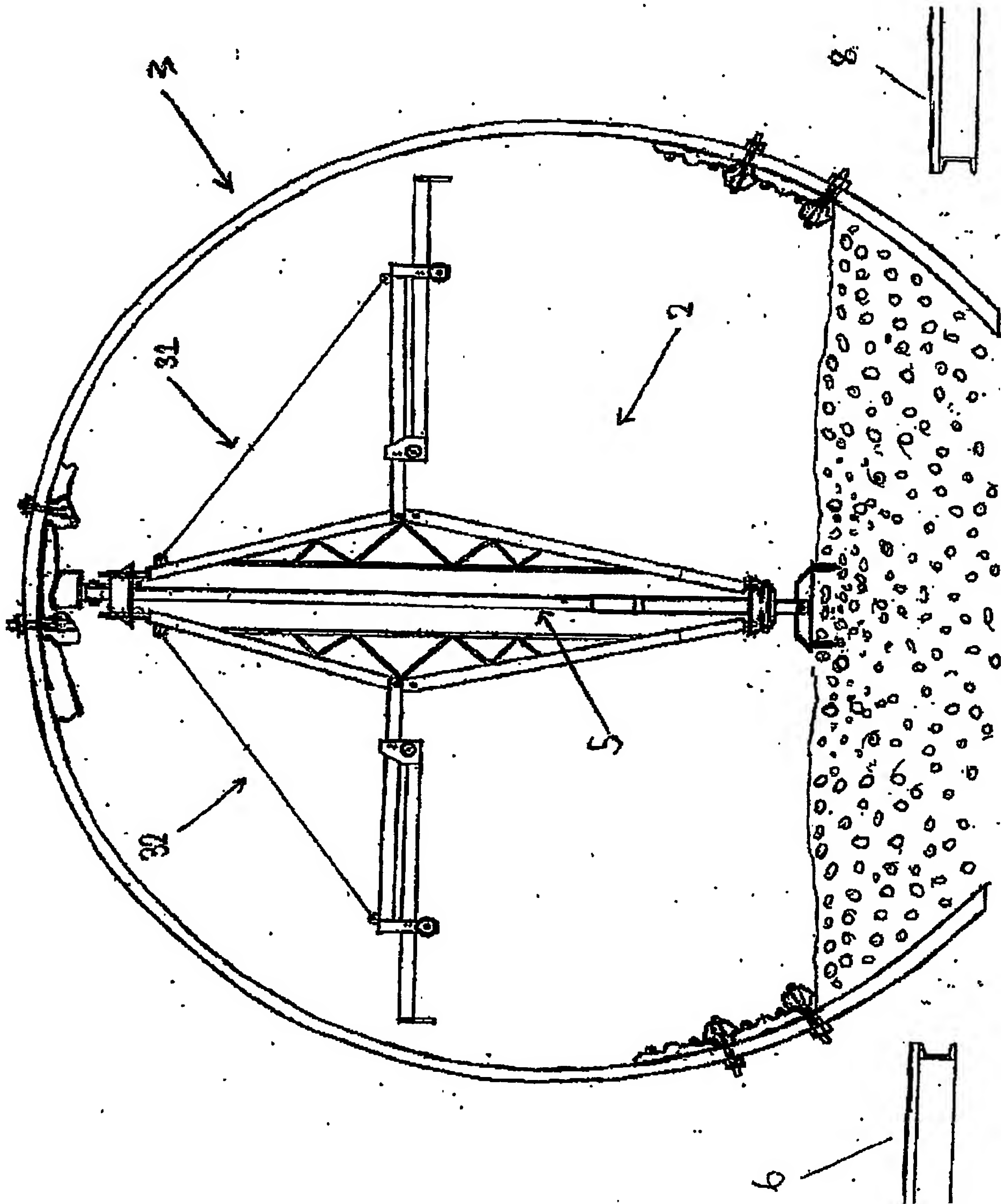


FIGURE 4/5

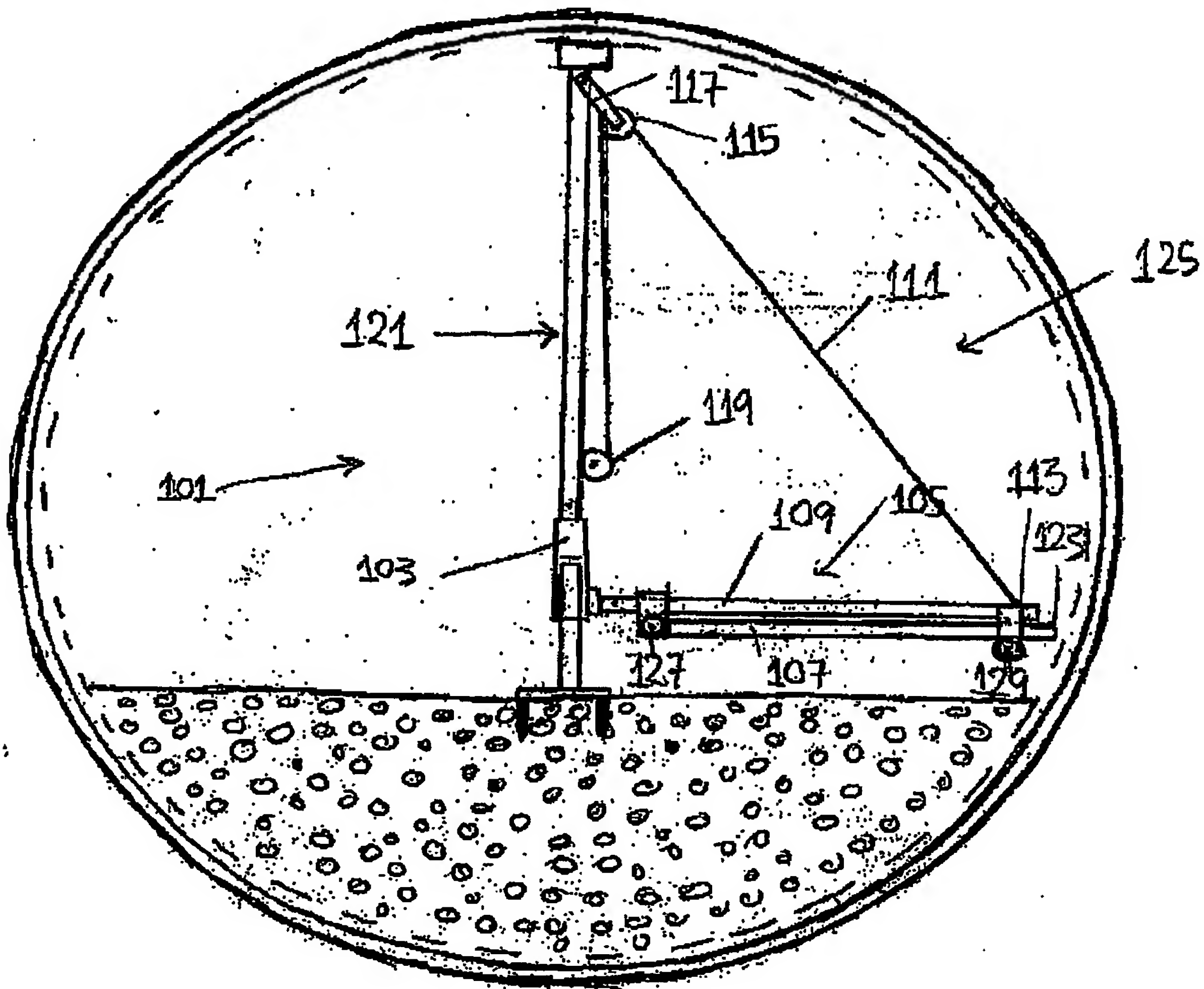


FIGURE 5/5

TOTAL P.28